AD 296 901

THE UNIVERSITY OF MICHIGAN

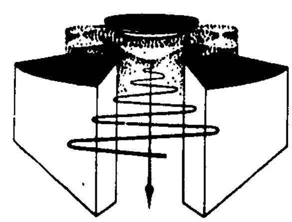
RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE

QUARTERLY PROGRESS REPORT NO. 10

Period Covering October 1, 1962 to January 1, 1963

ELECTRON PHYSICS LABORATORY

Department of Electrical Engineering



By: J. E. Boers
G. T. Konrad

Approved by: J. E. Rowe
January, 1963

CONTRACT WITH:

NAVY DEPARTMENT BUREAU OF SHIPS, ELECTRONICS DIVISION,
CONTRACT NO. NObsr-81403, INDEX NO. SF-0100201.

OFFICE OF RESEARCH ADMINISTRATION · ANN ARBOR

THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

QUARTERLY PROGRESS REPORT NO. 10

FOR

RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS

FOR THE 100-300 MC FREQUENCY RANGE

This report covers the period October 1, 1962 to January 1, 1963

Electron Physics Laboratory
Department of Electrical Engineering

By: J. E. Boers
G. T. Konrad

Approved by: J. E. Rowe
J. E. Rowe, Director
Electron Physics Laboratory

Project 03783

NAVY DEPARTMENT BUREAU OF SHIPS
ELECTRONICS DIVISION
CONTRACT NO. NObsr-81403
INDEX NO. SF-0100201

January, 1963

ABSTRACT

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

PERSONNEL

Scientific and Engineering Personnel		Time Worked in Man Months*
J. Rowe	Professor of Electrical Engineering	.18
C. Dolph	Professor of Mathematics	.32
C. Yeh	Associate Professor of Electrical Engineering	.50
R. Lomax	Visiting Assistant Professor of Electrical Engineering	.28
G. Haddad	Instructor of Electrical Engineering	.13
A. Singh	Research Engineer	.27
J. Boers	Associate Research Engineers	.95
G. Konrad		1.44
J. Kurtz		.61
A. Collins	Research Assistants	.16
J. Loh		1.25
W. Rensel		.46
C. Rhee		1.18
D. Terry		.23
R. Hsieh	Assistants in Research	.15
C. Kim		.20
L. Kistler		.54
A. Pajas		.46
D. Steele		.09
D. Wright		.96
K. McCrath	Electronics Technicians	.32
C. Murillo		.55
J. Pugh		.69
Service Personnel		10.67

* Time Worked is based on 172 hours per month.

QUARTERLY PROGRESS REPORT NO. 10

FOR

RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS

FOR THE 100-300 MC FREQUENCY RANGE

1. Introduction (G. T. Konrad)

Contract NObsr-81403 comprises a research and development program on high-power 100-300 mc Crestatrons. It is the aim to construct compact 100-watt Crestatrons employing permanent magnet focusing. Initially the tube will be tested in a solenoid to meet electrical specifications. Ultimately the permanent magnet focused tube will be ruggedized, as may be necessary, so as to meet environmental specifications. All this work is being conducted by the Bendix Research Laboratories on a subcontract from The University of Michigan.

Theoretical as well as experimental studies on high-perveance hollow-beam electron guns, in addition to electrostatic focusing systems initiated some time ago on this program, are being continued by The University of Michigan. The ultimate goal of these studies is to demonstrate the feasibility of using electrostatically focused high-power, hollow electron beams in microwave devices.

2. Beam Analyzer Tests (G. T. Konrad)

In order to check the characteristics of the electrostatic focusing system a focusing tester was constructed. This device, shown in Fig. 2.1, is versatile enough so that changes in the geometry of the focusing system may be made relatively easily. The electron gun is

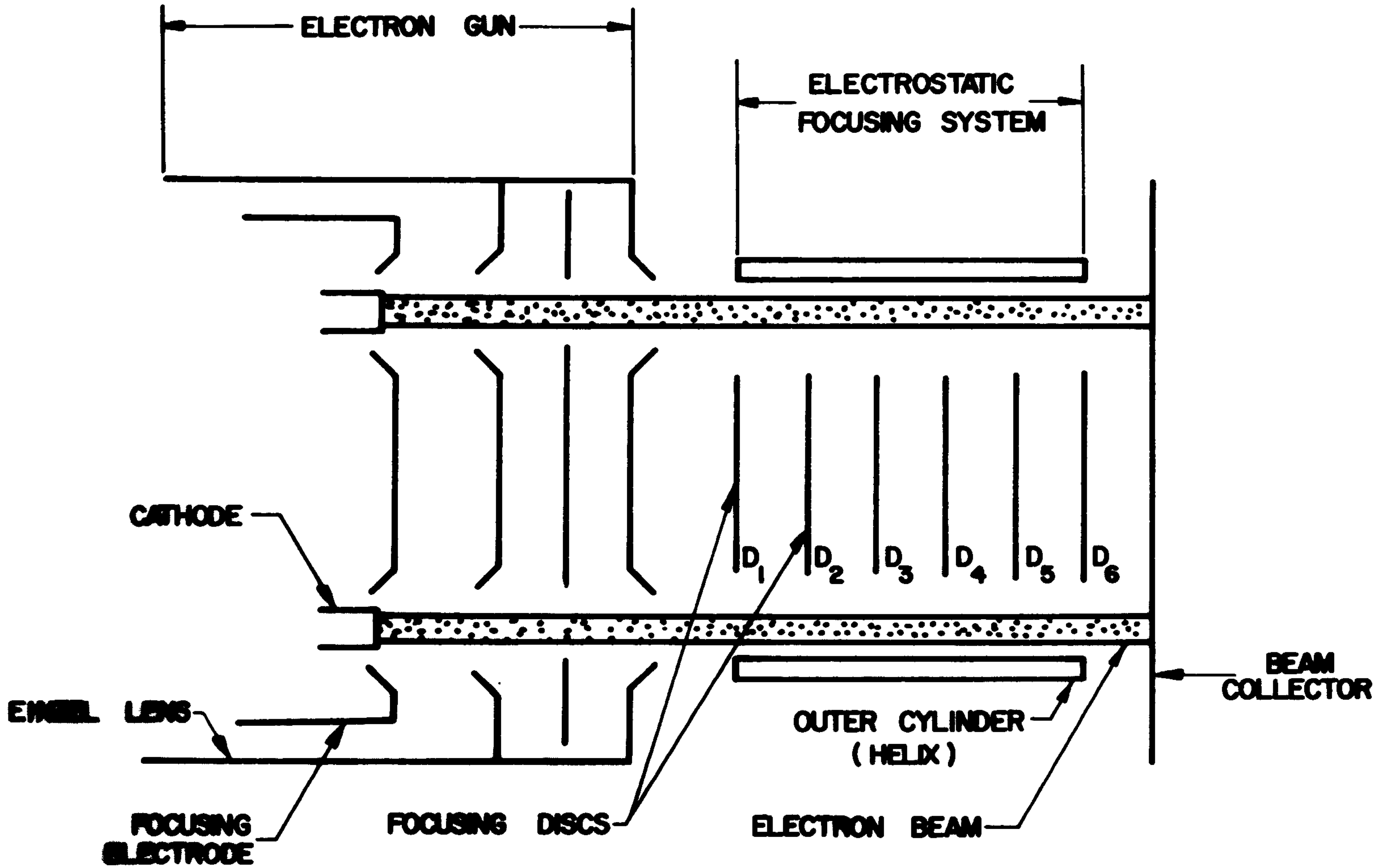


FIG. 2.1 SCHEMATIC DIAGRAM OF THE FOCUSING TESTER.

mounted in the beam analyzer in the usual fashion permitting it to be moved in a horizontal as well as vertical plane. The gun test data so obtained have been described in detail in previous progress reports on this program. The major change in the setup is that the pin-hole collector for sampling the beam has been replaced by the focusing tester.

As may be seen from Fig. 2.1 the focusing system consists of six disks and an outer cylinder representing the helix. Each of the disks has a separate external connection such that the voltages may be adjusted independently for optimum beam transmission. If it is necessary to move the outer cylinder with respect to the first focusing disk in order to adjust the profile of the electric field at the entrance to the electrostatic focusing system, this can be accomplished relatively easily by opening the beam analyzer and making the necessary adjustment. The beam collector consists of a thin tantalum sheet coated with carbon.

In all the experiments done with the focusing tester the lens voltage in the gun was adjusted for minimum anode interception. This, as was indicated during previous gun tests, assured the desired beam shape at the entrance of the electrostatic focusing system. It may be noted in general from the results to be presented that the gun transmission was not nearly as good as in the gun tests described in the last progress report. There the collector had been biased with a positive voltage which, it is believed, had a tendency to keep secondary electrons from returning to the anode and also corrected the field distribution within the final anode.

Basically three modes of operation were found to work for the focusing system. The first, although not always the best from the standpoint of overall beam transmission, is by far the simplest to achieve.

The disk voltages are set so that all the odd-numbered disks are at the high potential, V_+, and all the even-numbered disks are at the low potential, V_-. In fact

$$V_+ - V_o = V_o - V_- \quad , \tag{2.1}$$

where V_o is the beam voltage. Under these conditions it is found that the voltage on the outer cylinder, V_H, is usually slightly less than the beam voltage for best transmission. Figure 2.2 shows a plot of transmission as a function of V_H. Total transmission to the collector may be seen to be as high as 24 percent, while the transmission through the focusing system, neglecting gun interception, is nearly 60 percent. All tests to be described here were conducted at the relatively low anode voltage of 150 volts and a collector voltage of 350 volts. These were the highest potentials possible in the beam analyzer under cw conditions so that none of the parts became overheated. Since the focusing structure had been designed to operate at a much higher voltage, better beam transmission through the structure should be possible for higher beam voltages. This is confirmed by the rise in the upper curve in Fig. 2.2. Checking the system under pulsed conditions for higher voltages it was found that the total transmission increased only slightly while the transmission through the focusing system only could be increased considerably. It was, however, very difficult to obtain accurate readings due to current leakage along the ceramic support structures inside the gun and along the center of the disks.

Figure 2.3 shows curves for similar conditions except that the last disk is tied to the fifth disk electrically. This then forces the exit from the focusing system to be at the low potential, V_-. A marked increase in transmission was observed. The focusing system is able to

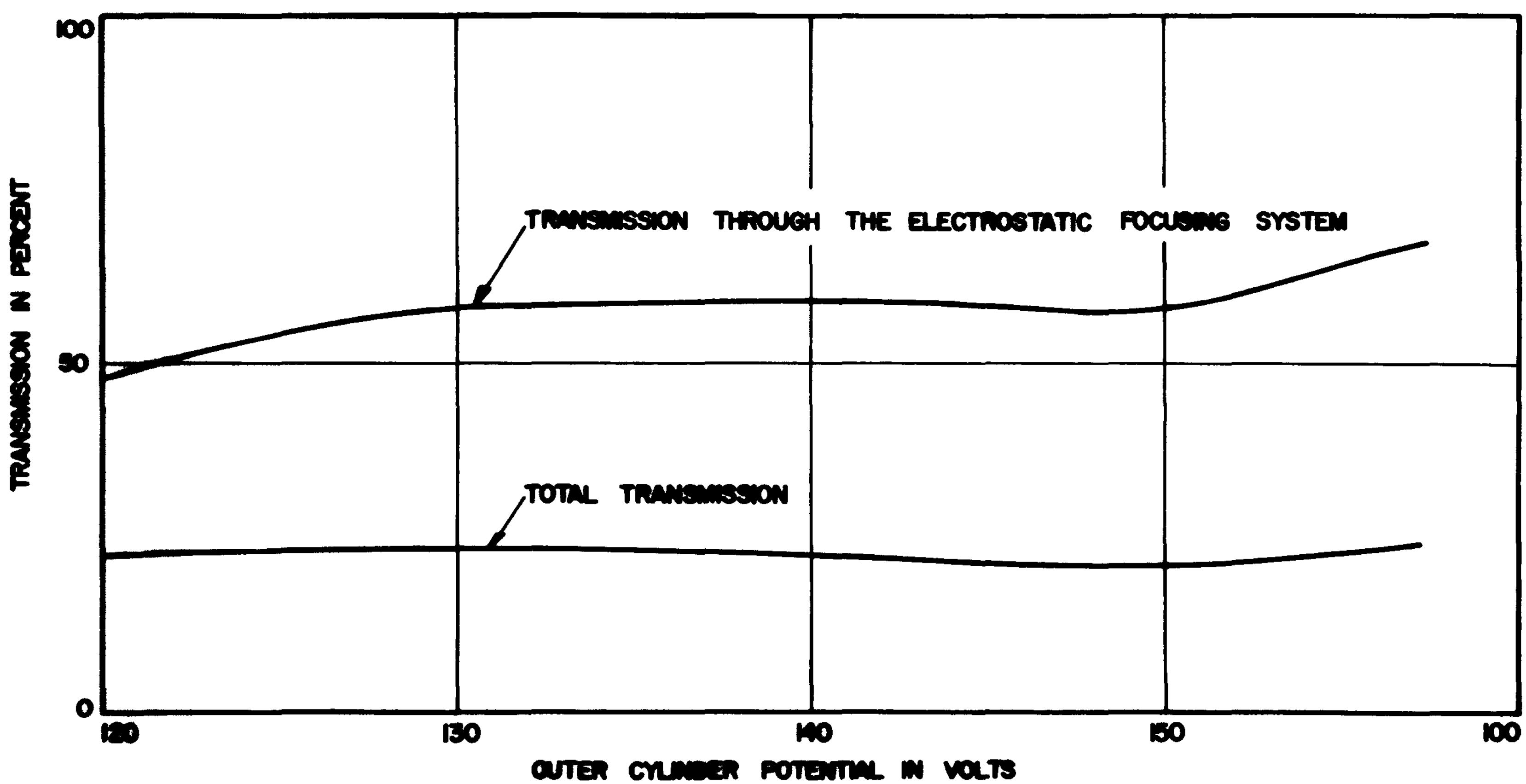


FIG. 2.2 OPTIMUM TRANSMISSION FOR THE CONDITION. $(V_{D_1} - V_o = V_o - V_{D_2})$

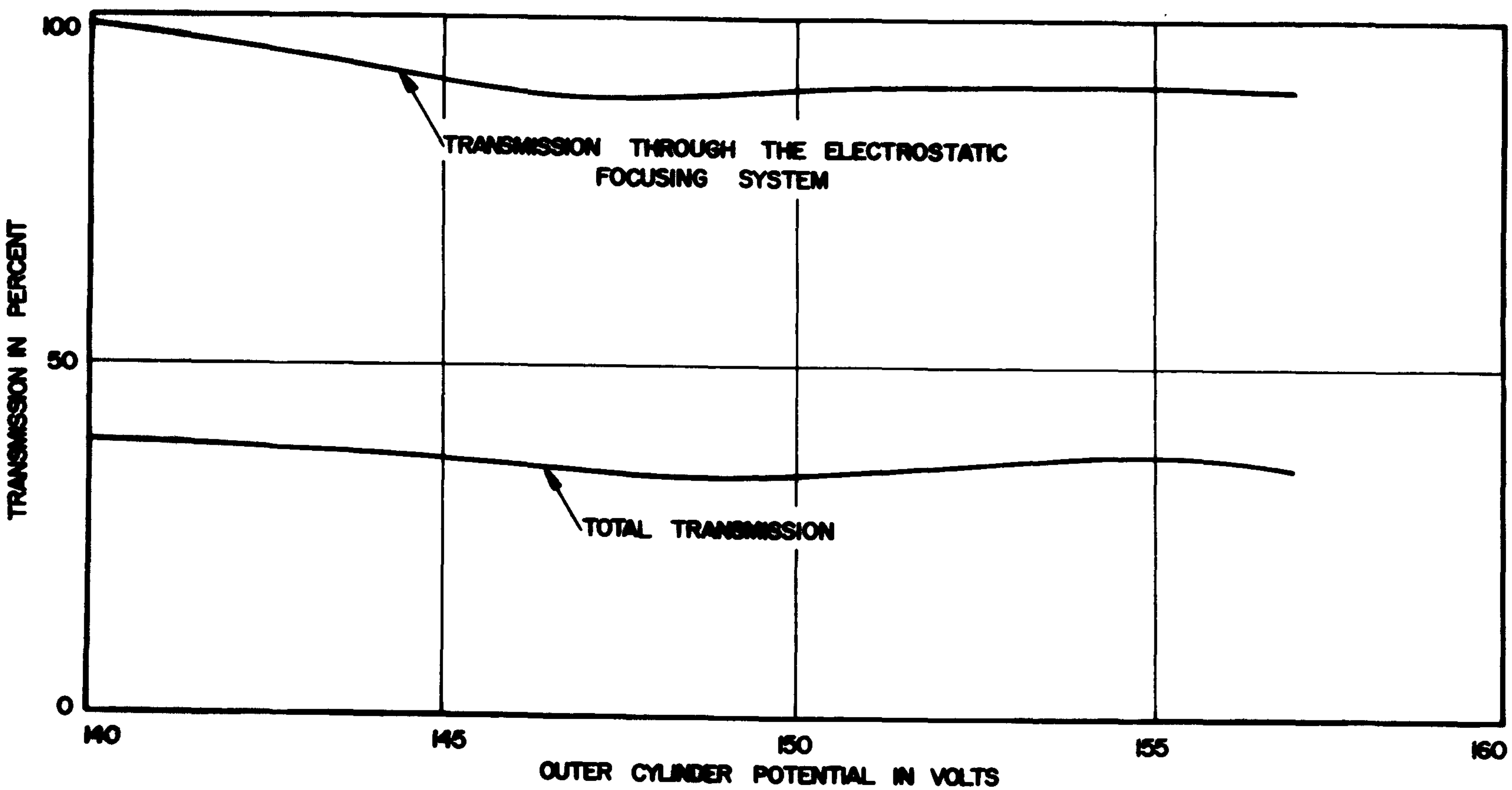


FIG. 2.3 OPTIMUM TRANSMISSION FOR THE CONDITION $V_{D_1} - V_o = V_o - V_{D_2}$. ($V_{D_5} = V_{D_6} = V_{D_1}$)

transmit approximately 90 percent of the current entering into it from the gun.

The second mode of operation is such that

$$V_{D_1} > V_o < V_{D_2} \tag{2.2}$$

and

$$V_{D_1} > V_{D_2} \ . \tag{2.3}$$

For each value of V_H all the disk voltages are adjusted independently for optimum transmission. Fairly good operation is thus achieved at rather low voltages as indicated in Fig. 2.4.

The third mode of operation is the most unexpected one from theoretical considerations. Here the first disk voltage is below the anode voltage such that

$$V_{D_1} < V_o < V_{D_2} \tag{2.4}$$

and

$$V_{D_1} < V_{D_2} \ . \tag{2.5}$$

The transmission observed under these conditions is quite good, however, as indicated in Fig. 2.5. As mentioned previously the focusing structure has been designed to operate at higher voltages so that this third mode of operation can be expected to work best only at the lower voltages.

In Fig. 2.6 the transmission is plotted as a function of $V_{D_1} - V_{D_2}$. This quantity is a measure of the strength of focusing in the system. For a beam voltage of 150 volts best transmission may be obtained for a focusing voltage of approximately 70 volts. The outer cylinder potential is of course optimized as in all previous tests. If one defines a focusing parameter, F, such that

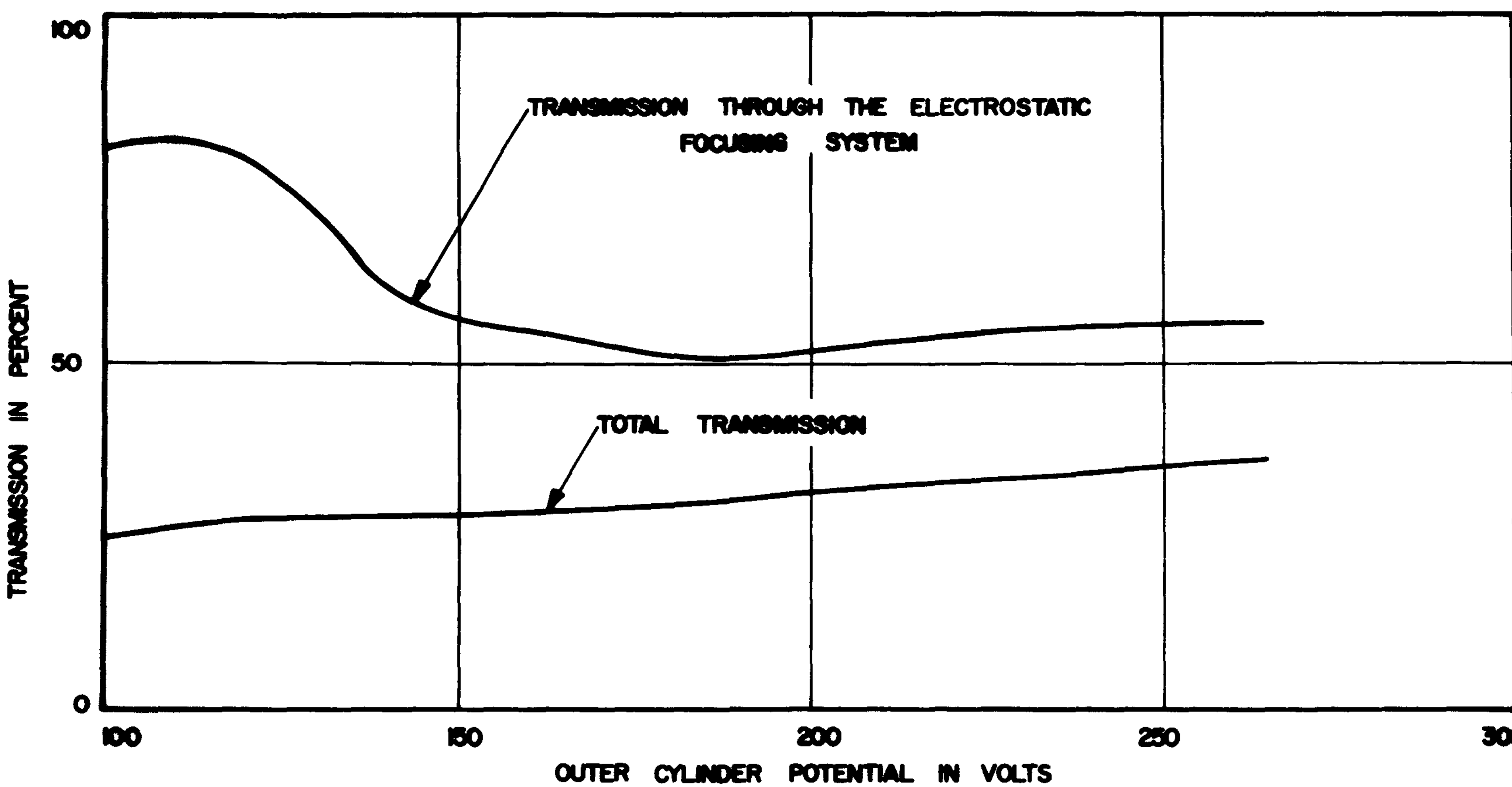


FIG. 2.4 OPTIMUM TRANSMISSION FOR THE CONDITION $V_{D_1} > V_{D_2}$.

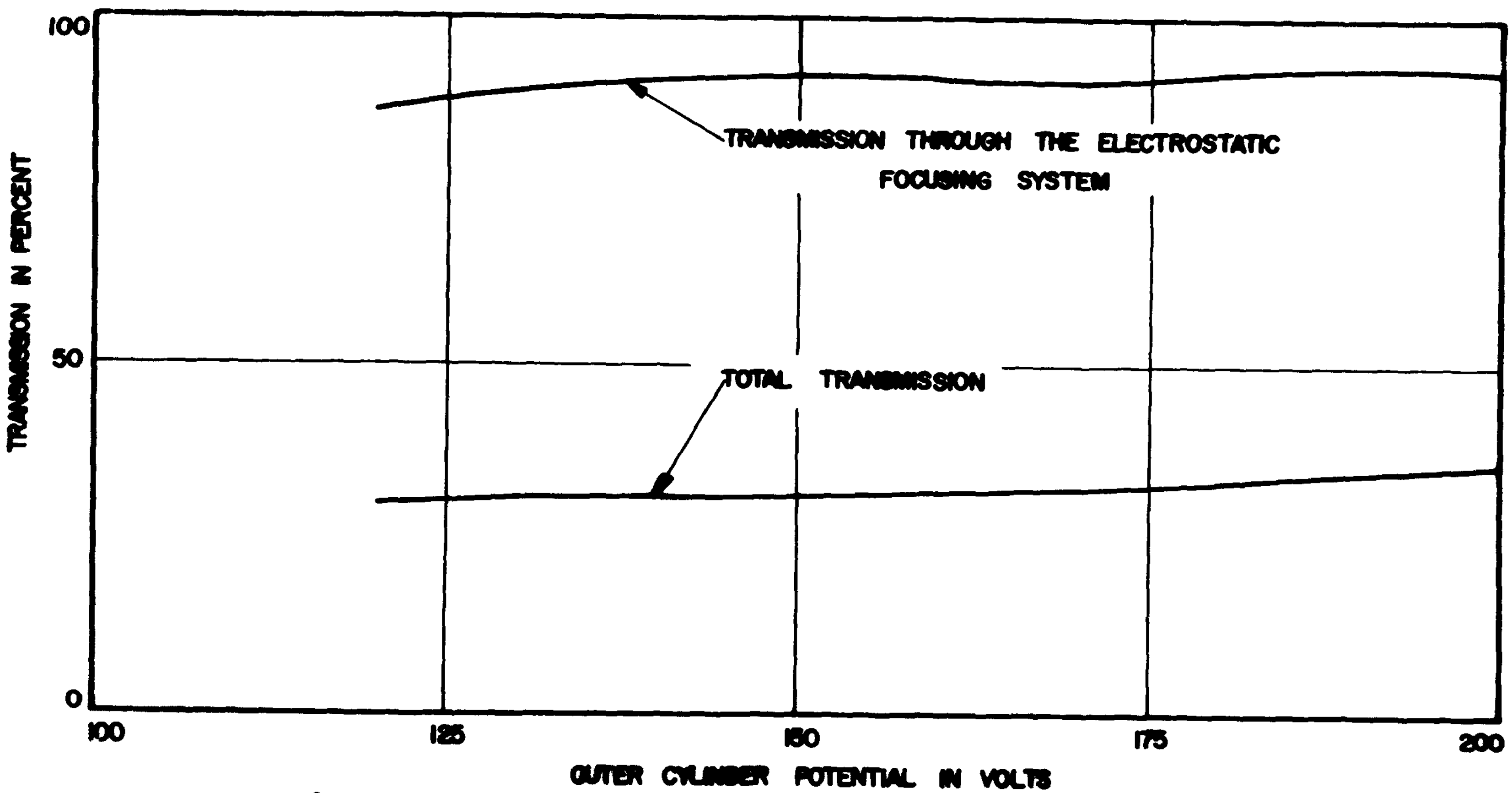


FIG. 2.5 OPTIMUM TRANSMISSION FOR THE CONDITION $V_{D_1} < V_{D_2}$.

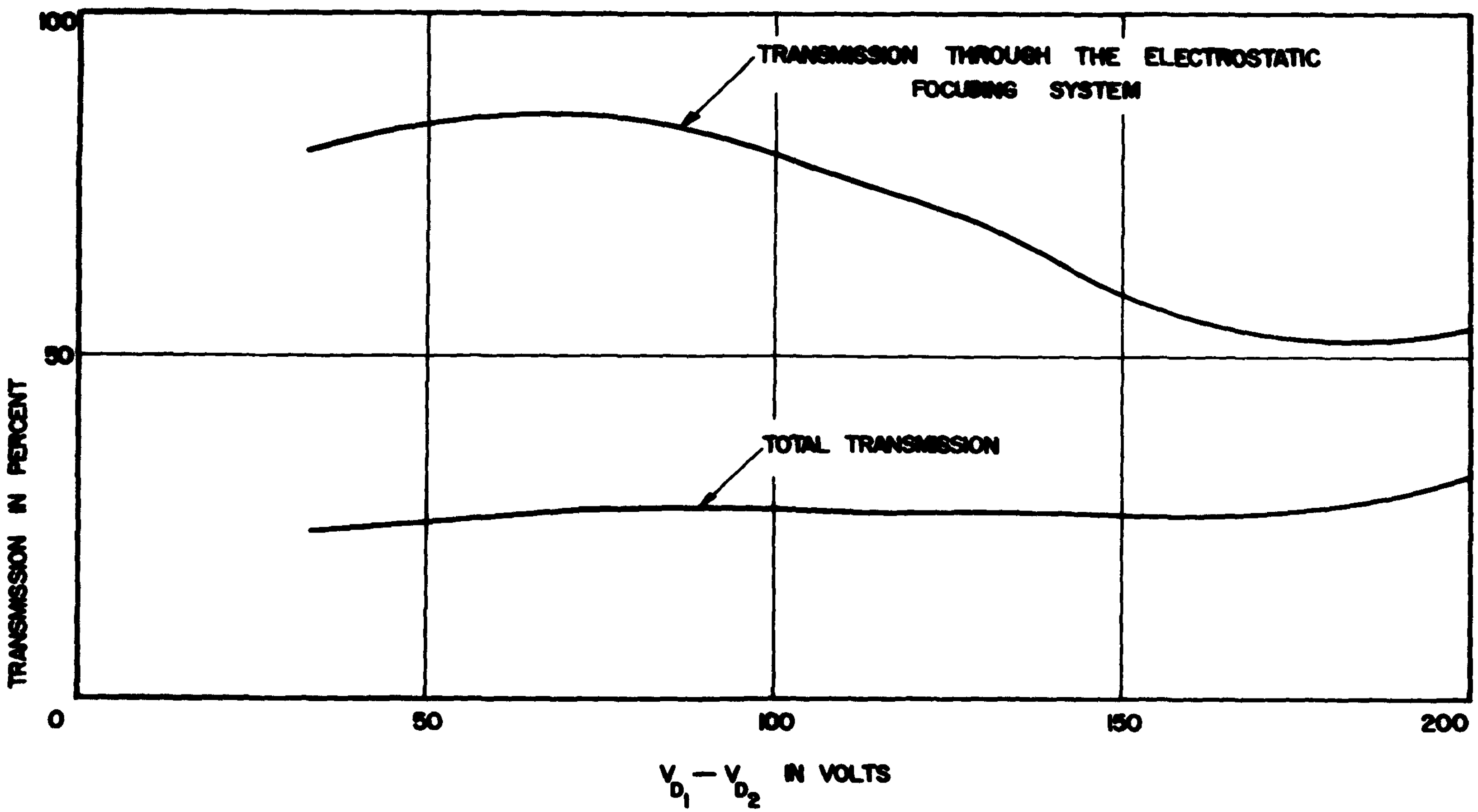


FIG. 2.6 OPTIMUM TRANSMISSION FOR THE CONDITION $V_{D_1} > V_{D_2}$.

$$F = \frac{V_+ - V_-}{V_o} , \qquad (2.6)$$

it is found that at the design voltage of 1500 volts F = 0.667, while at the low voltages employed in these tests F = 0.467. The beam is expected to be focused considerably more easily at the lower voltages, but since the values of F are quite comparable in the two cases it indicates that the electrons have quite strong radial velocity components requiring the relatively high value of F at these low voltages.

Figure 2.7 shows the best beam transmission attained as a function of anode voltage while all other voltages are optimized. Here the mode of operation described by Eqs. 2.4 and 2.5 was employed. It may be seen that most of the beam interception occurs inside the gun. This is believed to be at least partially due to secondaries returning to the anodes, hence increasing the interception.

3. Digital Computer Analysis of Electrostatically-Focused Electron Beams (J. E. Boers)

Results obtained from the digital computer program for the P_μ = 4.46 gun with the Einzel lens are shown in Figs. 3.1 and 3.2. Figure 3.1 shows the electron trajectories with the focusing (Einzel) lens electrode potential at one half of the anode potential. Some focusing is evident but the beam is still spreading after passing the focus electrode.

Figure 3.2 again shows the electron trajectories, this time with the focusing electrode at one fourth the anode potential. Now the beam is clearly converging after passing the focusing electrode and is still converging as it leaves the gun region.

In the above analysis a 120 x 100 point matrix is employed to describe the gun geometry and electric fields. Since this is already near

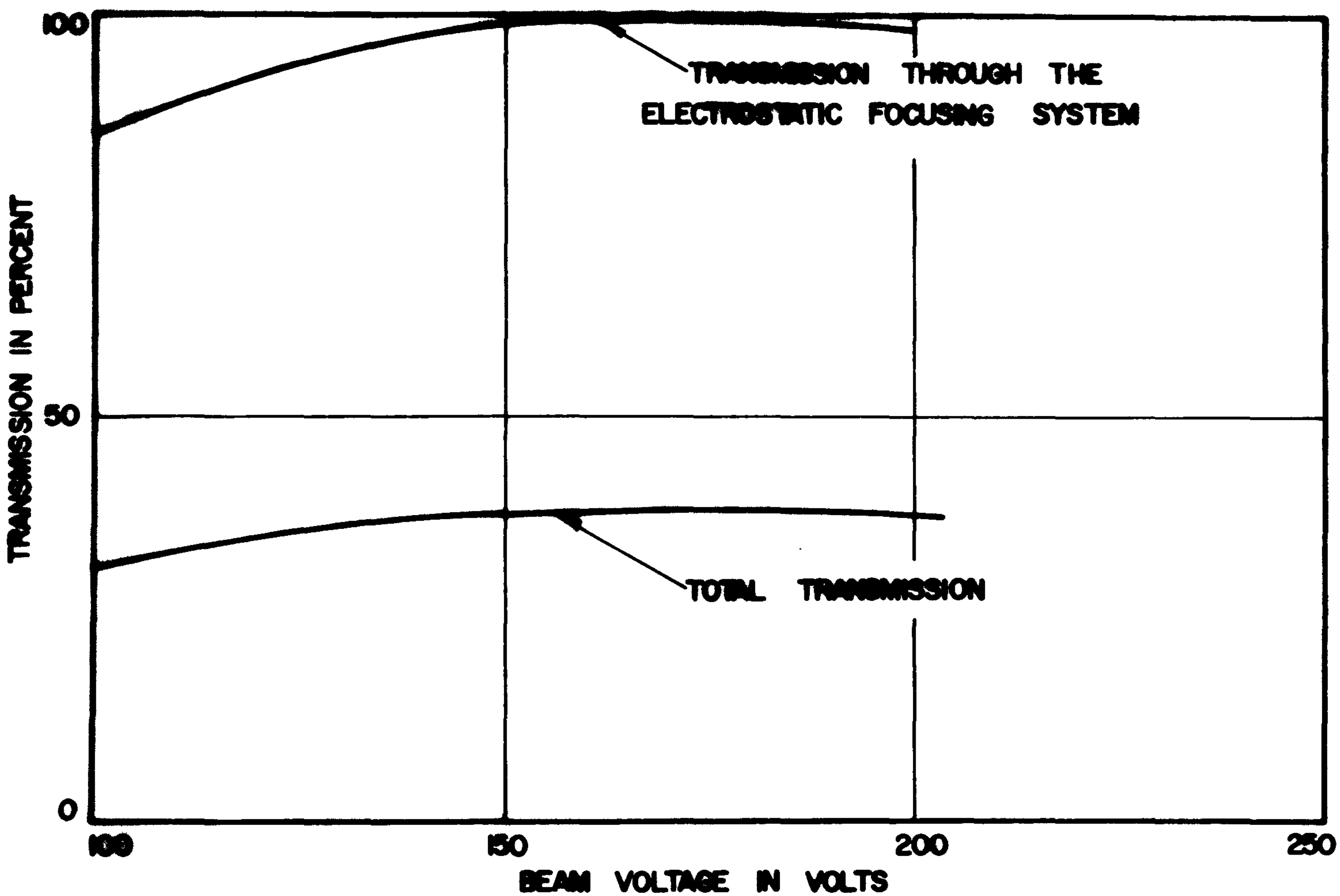


FIG. 2.7 OPTIMUM TRANSMISSION FOR THE CONDITION $V_{D_1} < V_{D_2}$.

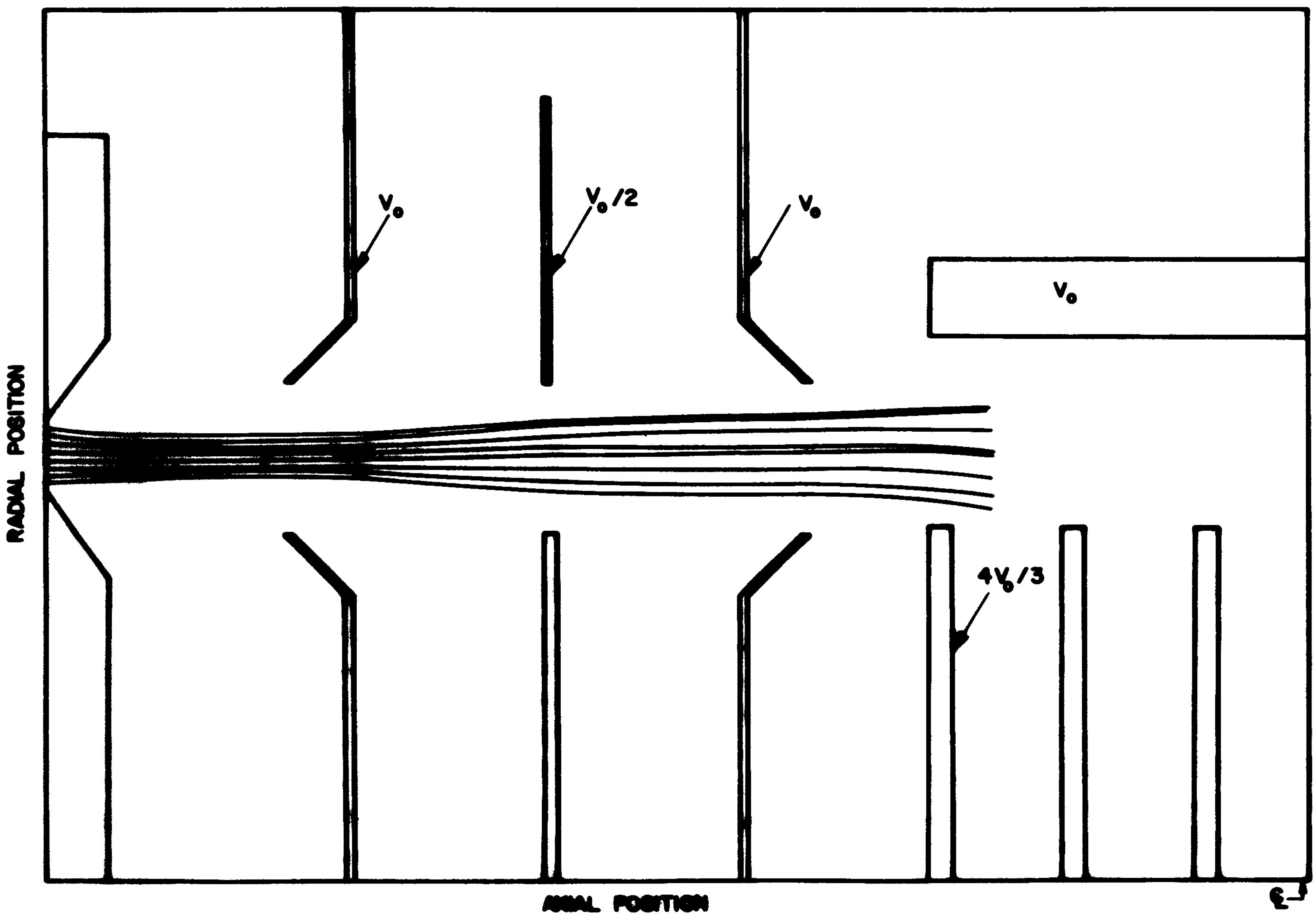


FIG. 3.1 ELECTRON TRAJECTORIES INSIDE THE P_μ = 4.46 HOLLOW-BEAM GUN. (V_L = $V_o/2$)

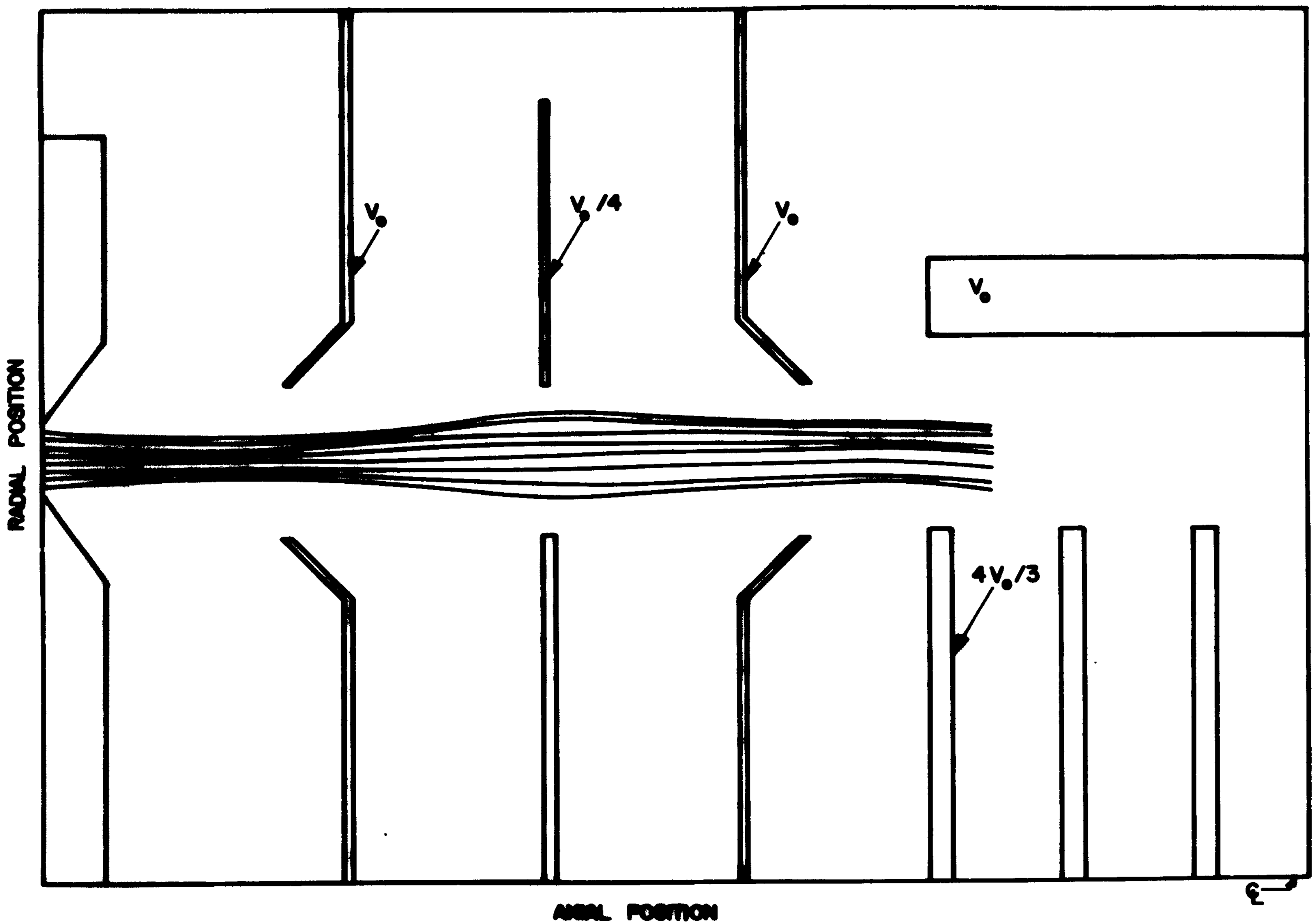


FIG. 3.2 ELECTRON TRAJECTORIES INSIDE THE $P_\mu = 4.46$ HOLLOW-BEAM GUN. ($V_L = V_o/4$)

the capacity of the computer, it was not possible to extend the beam immediately into the drift region. Thus the electron trajectories are obtained in two steps. First they are found for the gun region, such as in Fig. 3.2, and then using this information consisting of velocities and potentials along the last gun electrode as input data for the second step, the trajectories are continued to the collector. The results obtained for the second step consisting of the electrostatic focusing region are presented below.

The trajectories with the outer electrode held 30 volts below the final gun anode potential of 1500 volts are shown in Fig. 3.3. It is seen that approximately 40 percent of the beam current is intercepted on the first six focusing disks. The whole beam is drifting toward the axis and it appears that most of the electrons would be intercepted by the next 8 to 12 disks.

The outer electrode potential was then changed so that it was only 10 volts below the final gun anode and the trajectories for this condition are shown in Fig. 3.4. The electron interception on the first six electrodes was reduced to 20 percent of the total current but the beam as a whole still drifts toward the focusing disks and would probably be intercepted further down the tube.

Figure 3.5 shows the electron trajectories when the outer electrode is held at the same potential as the final gun anode. Due to an error in the input data for the electrostatic focusing region the outer electrons inadvertantly had their radial velocity components in the wrong direction and as a result are seen to drift toward the outer electrode faster than they should. Further examination of the digital computer data indicates that a slight radial acceleration has occurred and that the beam would

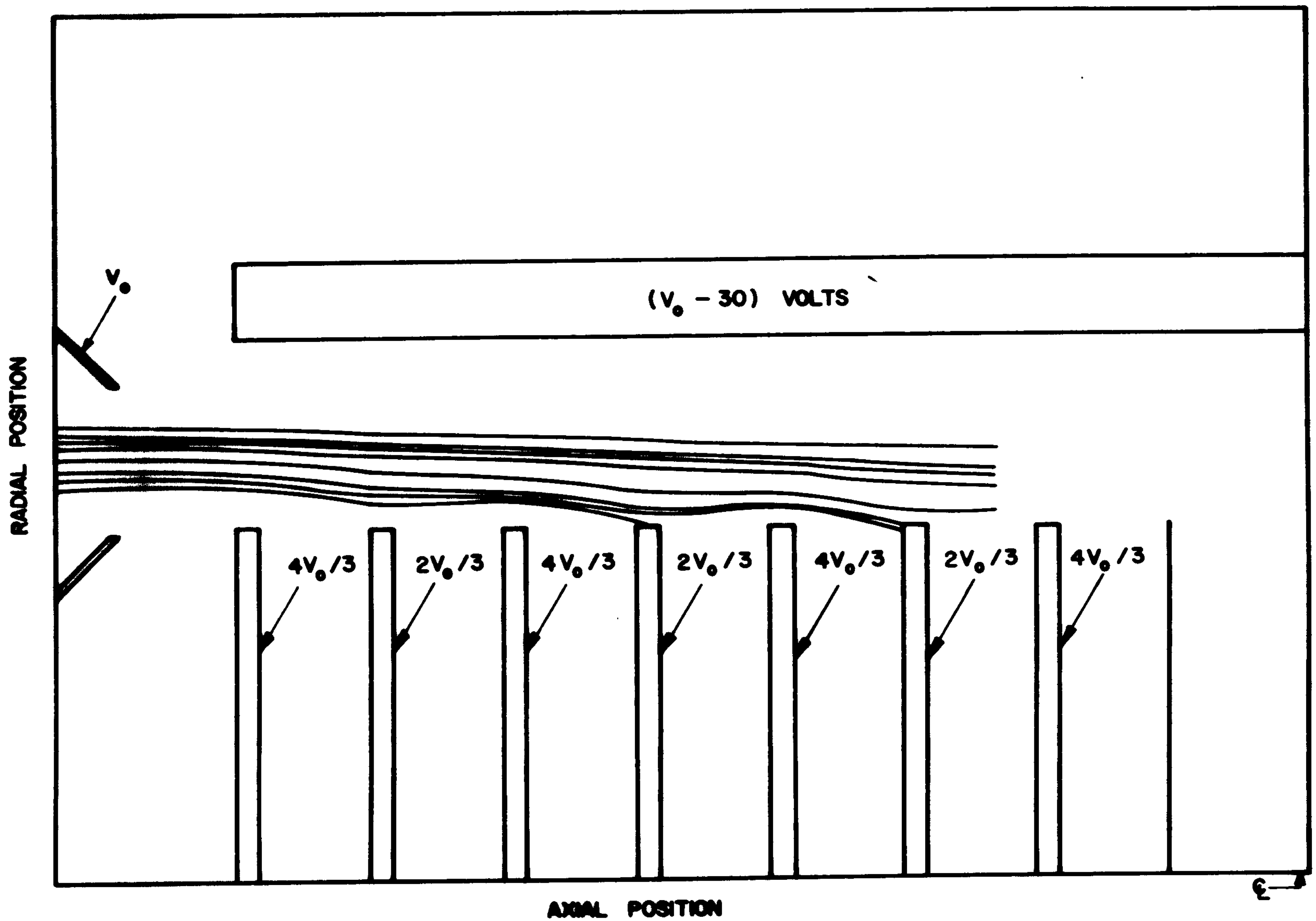


FIG. 3.3 ELECTRON TRAJECTORIES IN THE ELECTROSTATIC FOCUSING REGION.

(HELIX VOLTAGE = V_o - 30 VOLTS)

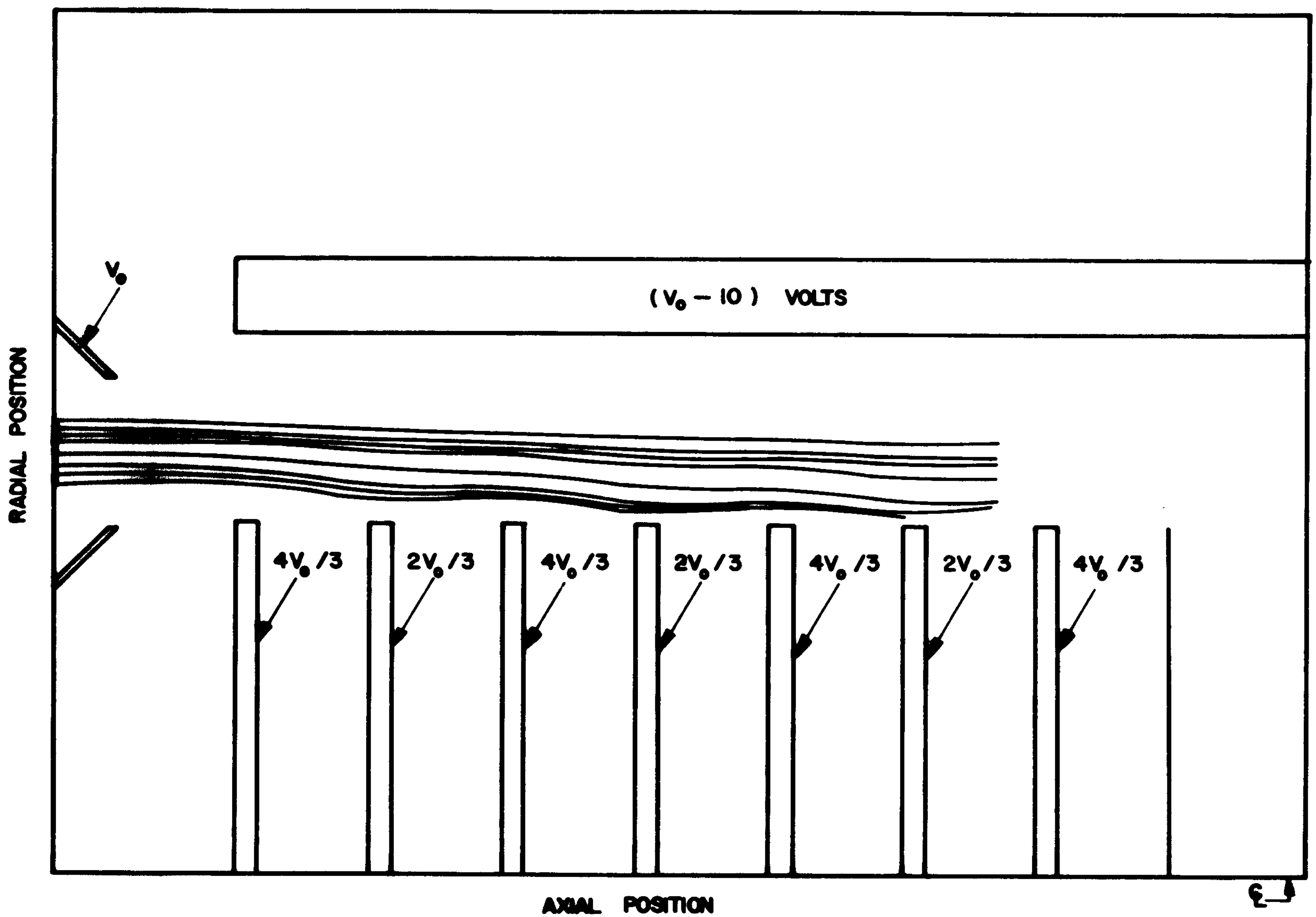


FIG. 3.4 ELECTRON TRAJECTORIES IN THE ELECTROSTATIC FOCUSING REGION.

(HELIX VOLTAGE = V_o - 10 VOLTS)

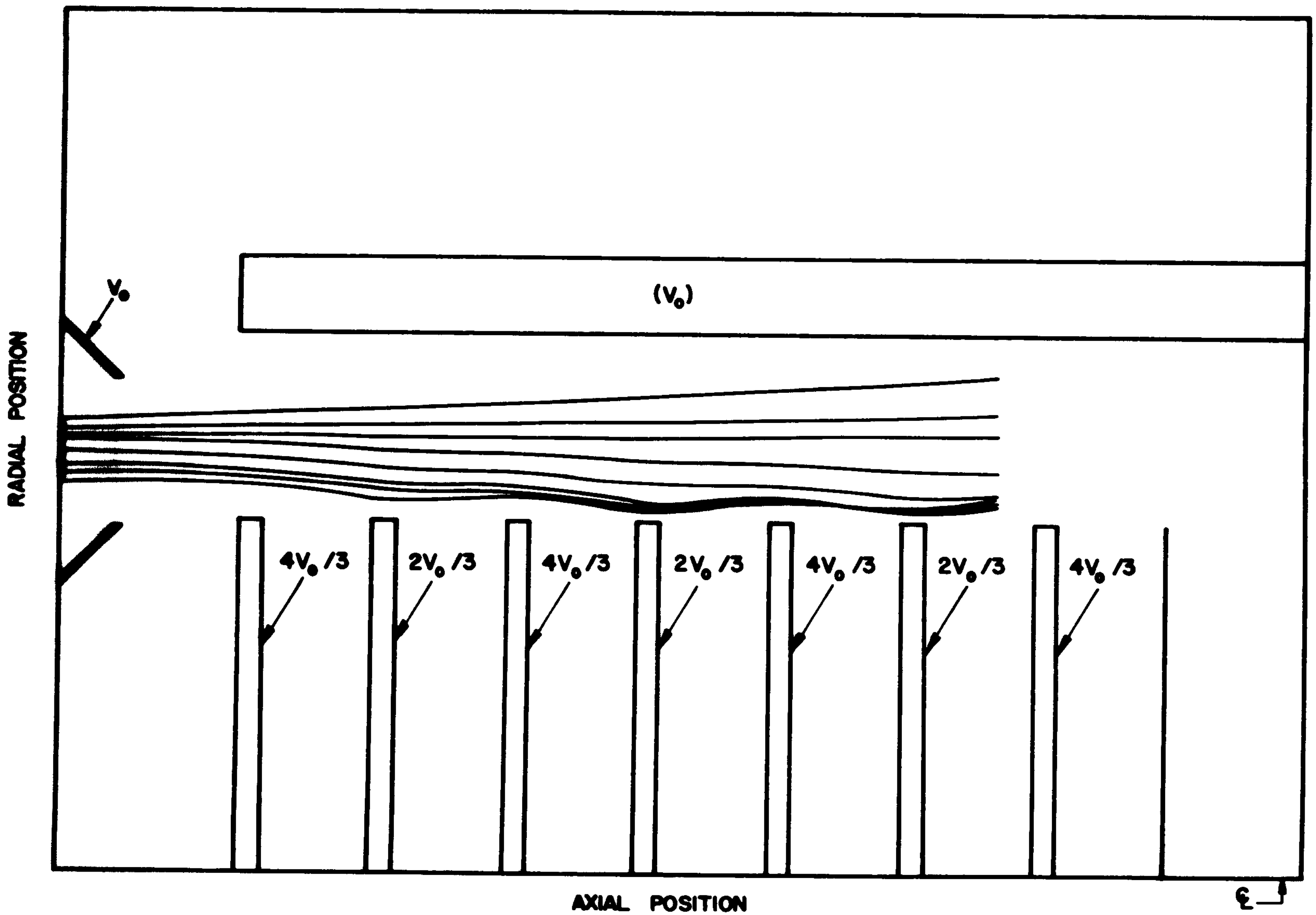


FIG. 3.5 ELECTRON TRAJECTORIES IN THE ELECTROSTATIC FOCUSING REGION.

(HELIX VOLTAGE = V_o VOLTS)

have spread regardless of the initial velocities. The electrons closer to the axis were properly started and are seen to drift within 0.010 inch of the disks.

While interception has not occurred on the disks the beam as a whole is spreading and interception would probably take place on the outer electrode. Also these electrons are "ideal" and do not display any thermal spread such as would occur in an actual device.

For an outer electrode potential of five volts negative with respect to the final anode voltage the trajectories in Fig. 3.6 were obtained. This beam appears to be fairly well behaved except for the fact that it is moving closer to the focusing structure as it proceeds toward the collector. This indicates that for the idealized conditions of this computer run, where thermal velocity spreading is not included, it may be possible to operate the outer electrode somewhere between zero and five volts below beam potential and obtain fairly good transmission to the collector.

Wherever interception occurs it may be noted that it usually takes place on the low voltage disks, indicating that the defocusing region between a high voltage disk and the succeeding low voltage disk is greater than the focusing action of the focusing regions for the values of space charge encountered in this beam. It may thus be necessary to use somewhat stronger focusing fields in order to obtain perfect beam transmission.

4. Work Conducted at the Bendix Research Laboratories*

4.1 Electron Gun. The University of Michigan has tested an electron gun of the type designed for this program. This gun was tested

---

* This material was submitted by Dr. J. G. Meeker of the Bendix Research Laboratories.

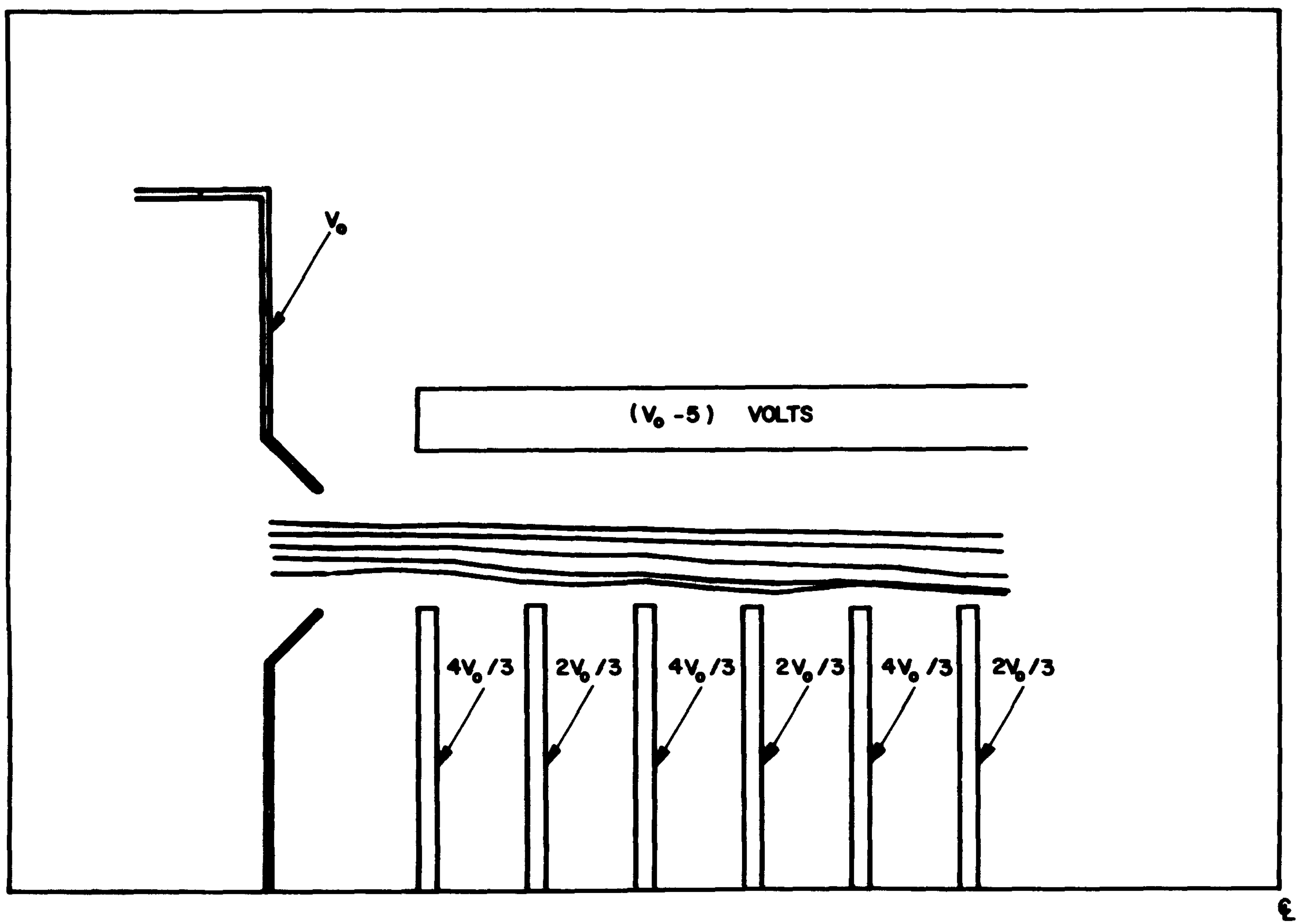


FIG. 3.6 ELECTRON TRAJECTORIES IN THE ELECTROSTATIC FOCUSING REGION.

(HELIX VOLTAGE = V_o - 5 VOLTS)

in the absence of a magnetic field. The beam profile is good at a point one-half inch from the gun, although there was substantial beam interception within the gun and the beam was expanding due to space-charge forces. Figure 4.1, a series of plots, shows beam density versus radial position at various axial distances from the anode. The design center of the beam is at a radius of 0.267 inch; however, in Fig. 4.1, due to an absence of magnetic field the beam is found outside this radius. This shift in radial distance is caused by space-charge forces and some lens effects in the gun.

At the Bendix Research Laboratories this gun has been operated in the required magnetic field with less than 10 percent interception in the gun and with less than one percent interception on a helical circuit similar to the one to be used in the final tube. Under continuous operation at 425 ma, a microperveance of 19.8 was achieved readily.

Gun operation under magnetic field conditions is therefore considered satisfactory for the present requirements. Appropriate minor changes will be made to reduce interception in the gun and to improve beam formation.

<u>4.2</u> <u>R-f</u> <u>Match</u>. The r-f match has been designed as a gradual transition with a direct coax to helix connection, referred to as a pin match. The VSWR of the match can be predicted and is dependent on the length of the gradual transition. The lowest VSWR for a given length of transition is obtained by varying Z exponentially with length, where Z is the transmission-line impedance. In this case, it can be shown that

$$|\Gamma| = \frac{|\sin\theta|}{2\theta} \ln \frac{Z_H}{Z_L} , \quad \theta \geq 2 , \qquad (4.1)$$

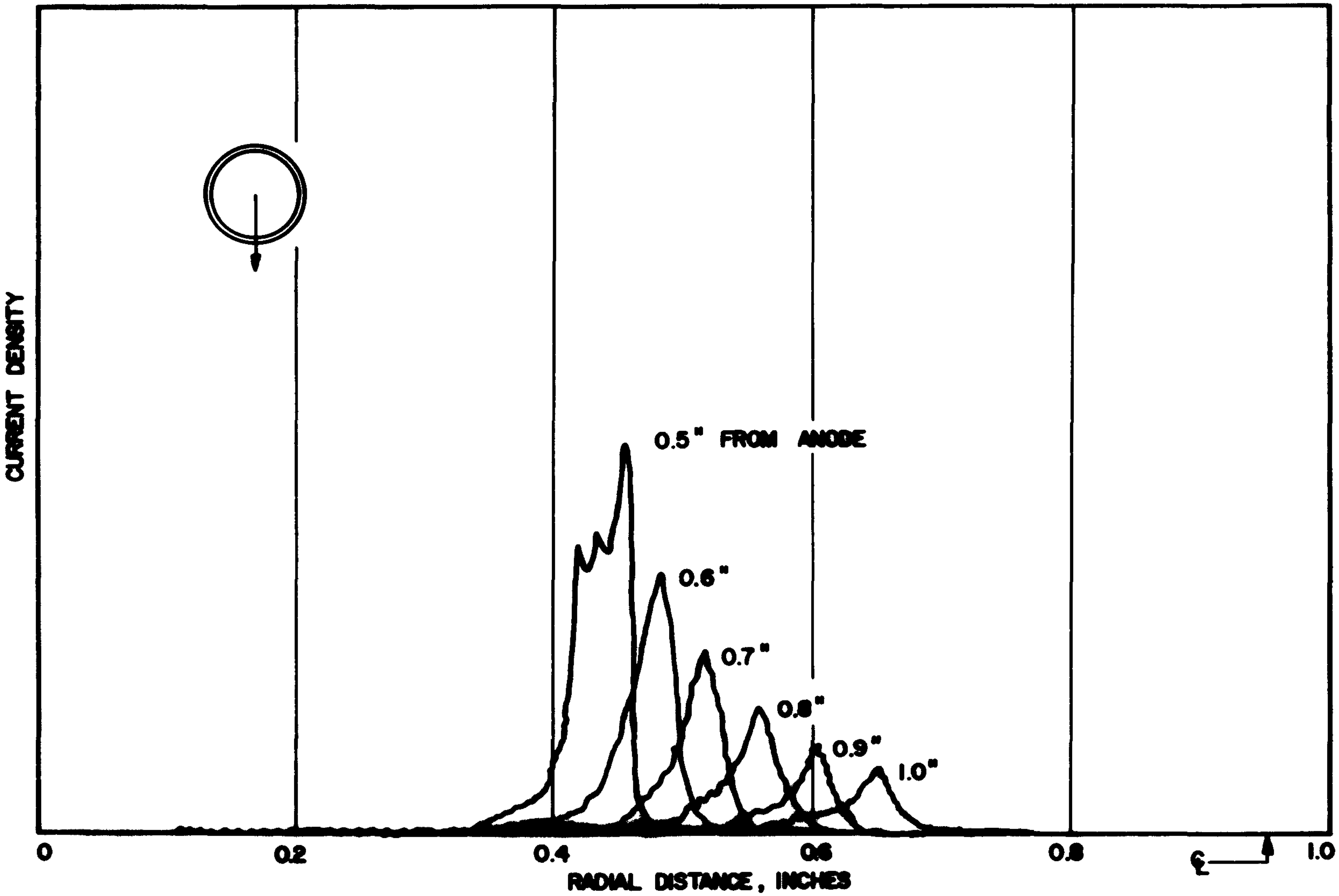


FIG. 4.1 CURRENT DENSITY CONTOURS FOR THE P_{μ} = 17.6 HOLLOW-BEAM GUN. (V_o = 900 v, PULSE LENGTH = 100 MICROSEC, PRF = 100 PER SEC.)

where Γ = voltage reflection coefficient,

θ = length of transition in radians = $2\pi L/\lambda$,

Z_H = high impedance at one end of the transition,

Z_L = low impedance at the other end of the transition,

L = length of transition.

For the Crestatron, Z_H is the helix impedance which is approximately 400 ohms, while Z_L is the impedance of the coaxial line and is approximately 50 ohms. The solid line of Fig. 4.2 is a plot for $Z_H/Z_L = 8$ and for a transition length from $0 \leq L/\lambda \leq 4$. The dotted line gives experimental results obtained with an actual transition. The tube now being assembled has a redesigned matching section which will work in the range of $0.9 \leq L/\lambda \leq 2.7$. With this matching section a maximum VSWR of 1.35 to 1 is expected.

4.3 Cold Tests on the Shielded Helical Circuit. Cold tests have been conducted on the helix mounted inside a shield as it will be in the final tube. Curve A of Fig. 4.3 shows the phase velocity of the helix with the shield in place, while Curve B shows the phase velocity without the presence of a shield. These two curves would not normally be expected to cross; but due to the higher dielectric loading in the presence of the glass envelope in the unshielded case, the phase velocity was slowed enough to cause the cross-over.

The dielectric loading factor was measured with the results shown in Table 4.1. Table 4.1 also lists the DLF which was originally assumed for the theoretical calculations. The two sets of DLF values are somewhat different and therefore new calculations of the helix impedance were performed. The results are given in Table 4.2 along with the previous calculations for comparison.

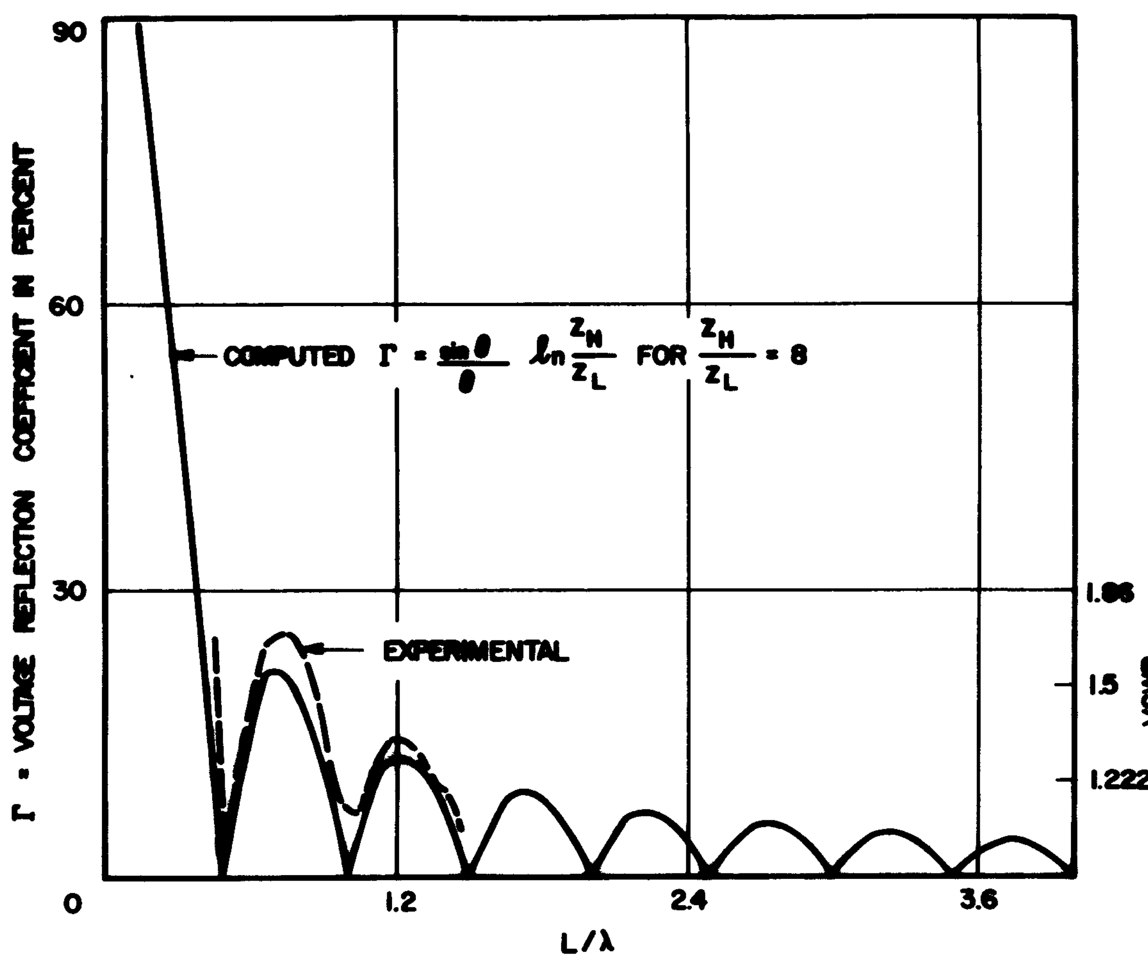


FIG. 4.2 VOLTAGE REFLECTION COEFFICIENT VS. Γ/λ.

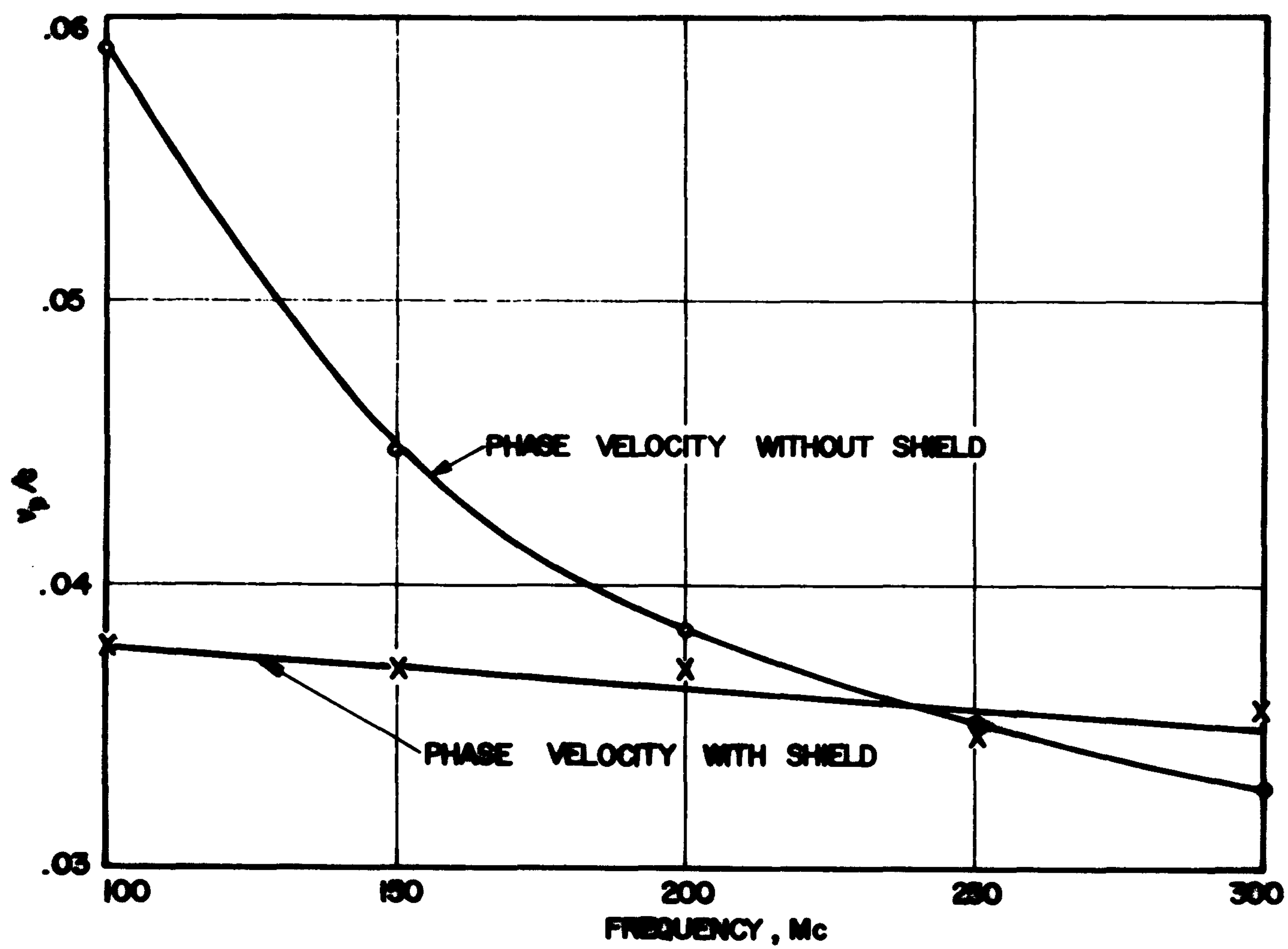


FIG. 4.3 PHASE VELOCITY VS. FREQUENCY OF HELICAL CIRCUIT WITH AND WITHOUT A CONDUCTING SHIELD.

Table 4.1

Dielectric Loading Factors

Frequency	Measured DLF	Previously Assumed DLF
100	0.871	0.702
200	0.873	0.811
300	0.874	0.858

Table 4.2

Interaction Impedances

Frequency	Impedance K (Ohms)	Previously Calculated K (Ohms)
100	387	255
200	210	160
300	75	65

In addition, cold tests were conducted to measure the impedance using the perturbation of the phase velocity by a thin rod along the axis of the helix. Although these data points were scattered rather widely, they tended to average near those values which were computed using the measured DLF values of Table 4.1. The experimental test setup is being modified to give more accurate results and the impedance measurements will be repeated in order to confirm the computed values given in Table 4.2.

4.4 Status of Tube Assembly. The first tube was to have been completed by the end of November, 1962, but unexpected difficulties were encountered with the r-f matching sections. In addition problems presented themselves in making the brazes around the r-f feedthroughs vacuum-tight. At present this is the only factor delaying assembly of the tube. It is expected that the first tube will be completed in the near future, however.

Figure 4.4 shows an exploded view of a complete tube. Once the tube has been processed it is expected that some of the time lost due to assembly difficulties can be made up by rapid testing and evaluation of the tube.

5. Summary and Future Work (G. T. Konrad)

During the coming quarter the $P_{\mu} = 4.46$ gun will again be operated in the beam analyzer in conjunction with the focusing tester. Some efforts will be made to prevent secondary electrons from returning to the gun anode. In addition the current leakage along some of the ceramic supporting structures will be eliminated so that more meaningful results can be obtained even at higher operating voltages.

The present $P_{\mu} = 4.46$ gun will be scaled to a microperveance value of 20. This represents an increase in the perveance of nearly 4.5. The geometry of the hollow beam will be kept approximately the same, but the current density at the cathode will increase to a value of 1.5 amps/cm^2. The beam power will be approximately 3 kw. This design will then be programmed for the digital computer and electron trajectories will be obtained within the gun region and in the electrostatic focusing system to be designed.

During the coming quarter it is expected that a metal-ceramic tube will be tested in a solenoid. Some of the cold tests described in this progress report will be complemented with more complete data. The design of the depressed potential collector will be completed and construction of a tube using such a collector will get underway.

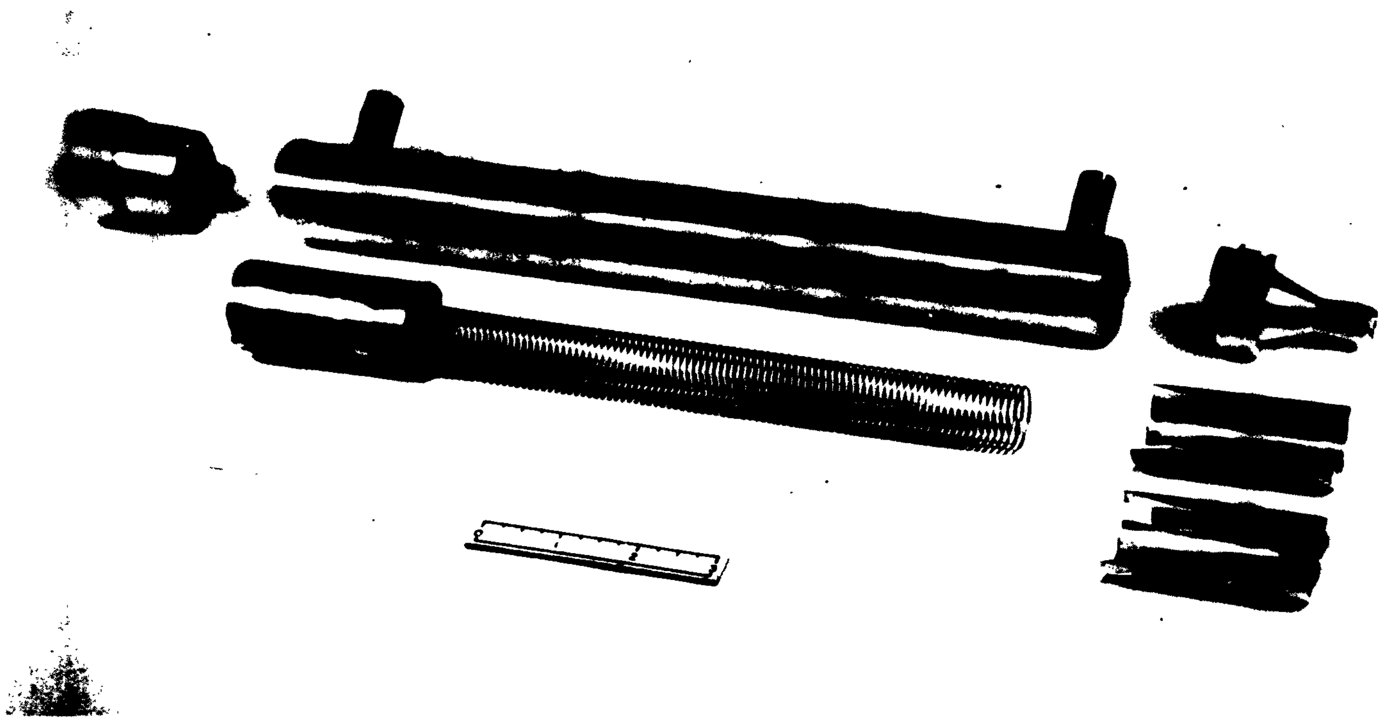


FIG. 4.4 EXPLODED VIEW OF THE CRESTATRON SHOWING COMPONENT PARTS.

DISTRIBUTION LIST

No. Copies	Agency
1	Commanding Officer and Director, U. S. Navy Electronics Laboratory, San Diego 52, California
2	Commander, ASD, Wright-Patterson Air Force Base, Ohio, ATTN: ASRN
1	Commanding Officer, Diamond Ordnance Fuze Laboratories, Electron Tube Branch, Washington 25, D. C.
2	Commanding Officer, U. S. Army Signal Research and Development Laboratory, Electron Devices Division, Fort Monmouth, New Jersey
1	Commander, New York Naval Shipyard, Material Laboratory, Code 924, Naval Base, Brooklyn 1, New York
2	Chief, Bureau of Naval Weapons, Department of the Navy, Washington 25, D. C., ATTN: RAAV-4423
1	Chief, Bureau of Ships, Department of the Navy, Washington 25, D. C., ATTN: Code 691A4
4	Chief, Bureau of Ships, Department of the Navy, Washington 25, D. C., ATTN: Code 335
1	Director, U. S. Naval Research Laboratory, Washington 25, D. C., ATTN: Code 5240, Dr. S. T. Smith
2	Director, U. S. Naval Research Laboratory, Washington 25, D. C., ATTN: Library
2	Advisory Group on Electron Tubes, 346 Broadway, 8th Floor, New York 13, New York
1	Commanding General, Rome Air Development Center, Griffiss Air Force Base, Rome, New York, ATTN: Documents Library RCOIL-2
1	Westinghouse Electric Corporation, P. O. Box 284, Elmira, New York, ATTN: Technical Library
1	Microwave Electronic Tube Company, Inc., Salem, Massachusetts, ATTN: Technical Library
1	Radio Corporation of America, Power Tube Division, Harrison, New Jersey

No. Copies	Agency
1	Microwave Associates, Burlington, Massachusetts, ATTN: Technical Library
1	S-F-D Laboratories, 800 Rahway Avenue, Union, New Jersey, ATTN: Technical Library
1	Tucor, Inc., 18 Marshall Street, South Norwalk, Connecticut, ATTN: Technical Library
1	Litton Industries, 960 Industrial Road, San Carlos, California, ATTN: Technical Library
1	Dr. G. Rosselot, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Detroit 35, Michigan
1	Dr. John G. Meeker, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Detroit 35, Michigan
1	Mr. L. Millett, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Detroit 35, Michigan
3	Mr. A. G. Peifer, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Detroit 35, Michigan
1	Commander, Rome Air Development Center, Griffiss Air Force Base, Rome, New York, ATTN: Mr. H. Chiosa, RCLRR-3
1	Bendix Corporation, Systems Division, 3300 Plymouth Road, Ann Arbor, Michigan, ATTN: Technical Library
1	Strand Engineering Company, 7300 Huron River Drive, Dexter, Michigan, ATTN: Mr. John Strand
10	Commander, Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Virginia
1	The University of Michigan, Willow Run Laboratories, Ypsilanti, Michigan, ATTN: Dr. J. T. Wilson
1	The University of Michigan, Willow Run Laboratories, Ypsilanti, Michigan, ATTN: Dr. Newbern Smith
1	The University of Michigan, Willow Run Laboratories, Ypsilanti, Michigan, ATTN: Mr. Robert L. Ohlsson

No. Copies	Agency
1	Bendix Corporation, Red Bank Division, Eatontown, New Jersey, ATTN: Mr. J. M. Wyman
1	Mr. J. Enright, ASRNET-1, Electronic Technology Laboratory, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio
1	Dr. J. Needle, Sylvania Microwave Tube Laboratory, Inc., 500 Evelyn Avenue, Mt. View, California
1	Raytheon Company, Burlington, Massachusetts, ATTN: Technical Library
1	Director, U. S. Naval Research Laboratory, Washington 25, D. C., ATTN: Mr. L. A. Cosby, Code 5437

AD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work
I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work
I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work
I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work
I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ____________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work

I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ____________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work

I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ____________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work

I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED

AD ____________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by J. E. Boers and G. T. Konrad. January, 1963, 28 pp. incl. illus. (Contract No. NObsr-81403, Index No. SF-0100201)

Data on the electrostatic focusing system mounted in a beam analyzer is presented. For the voltages employed in the tests quite good transmission through the focusing structure has been observed. In addition rather complete data in the form of trajectory plots obtained from a digital computer program for the hollow-beam gun as well as the focusing system are presented. The hollow electron beam is shown to be focused quite well throughout the system.

Work on the 100-300 mc metal-ceramic Crestatron is described. Some of the cold-test data obtained somewhat modifies the original calculations, but does not necessitate any design changes. The present status of tube construction is given.

UNCLASSIFIED

1. Beam Analyzer Tests
2. Digital Computer Analysis of Electrostatically-Focused Electron Beams
3. Work Conducted at the Bendix Research Laboratories
4. Summary and Future Work

I. Boers, J. E.
II. Konrad, G. T.

UNCLASSIFIED